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Examination of the causes of mortality in non-beak-trimmed pure line laying hens with special regard to aggression

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ABSTRACT - The experiment was started with 1,508 Rhode Island Red (RIR) and 1,820 Rhode Island White (RIW) type non-beak-trimmed day-old pullets, which originated from 58 RIR and 70 RIW different pedigree cocks, respectively. From all of the 128 cocks 26 half sibling offspring were tested. The pure line pullets were raised up to 18 weeks of age in a closed building, in deep litter pens and moved to the laying house and placed into three types of keeping systems [furnished cage, alternative pen (litter and floor) and conventional cage] thereafter. The number of dead birds and the cause of mortality were recorded daily during the whole rearing and egg-laying period, up to 72 weeks of age. During the rearing period the most frequent cause of mortality was wasting (due to feed intake refusal), which accounted for nearly 36% of the total mortality. Aggression was responsible for 28.3% of the total mortality. Depending on the type of the pullets (RIR or RIW), differences were observed in the frequency of occurrence of mortality causes. For example, oedema and beak deformation occurred only in the RIR, whereas technological injury and aggression only in the RIW pullets during the rearing period. During the egg-laying period aggression was the most common cause of mortality. Its lowest occurrence was observed in the alternative pens. In both of the examined types there were cocks, whose offspring died exclusively by aggression, and cocks, whose offspring did not show any loss due to aggression. The ratio of these cocks differed significantly (P<0.05) between the two types examined. Based on the results it was established that the genetic background has significant effect on the mortality caused by aggression in non-beak-trimmed laying hens.

Keywords: pullet, laying hen, feather pecking, aggression, cannibalism

INTRODUCTION

Animal breeders are sometimes encountered with binding regulations that they find difficult to identify with, on the basis of their professional experience. However, in order to stay sustainable and to remain competitive, they need to adapt to these regulations.

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One of these regulations is the EU Council Directive 99/74/EC of 19 July (1999), which laid down the minimum standards for the protection of laying hens, and prohibited the use of the conventional cage system in the European Union member countries from the 1st of January 2012. According to the provisions of the Annex to this Directive, the mutilation of animals in the EU is also prohibited, but in order to prevent feather pecking and cannibalism, beak trimming may be authorised by individual member states, if it is carried out by trained personnel up to 10 days of age of the animals.

In spite of the circumstances mentioned above, Denmark, Finland, Sweden and Germany from the EU member states have banned beak trimming simultaneously with the technological change, while the United Kingdom, France and the Netherlands are considering the introduction of banning. However, the application and spread of the alternative housing systems, as well as the continuously increasing rejection of beak trimming in Europe, raised serious animal welfare problems.

Despite the original intention of the breeders, the selection, for decades, in cages, favoured the outstandingly productive, but aggressive individuals, which are inclined to feather pecking, which can lead to massive cannibalism. In small groups (4-5 hens/cages), this type of social stress was not significant, or was possible to prevent effectively by beak trimming of the animals with thermo-cautery, laser or infra-red light (*Guesdon et al*., 2006; *Shinmura et al*., 2006; *Dennis et al*., 2009). However, in larger group numbers, in those housing systems that enabled greater freedom (alternative, run-out, free/eco/organic housing) for the hens, this can lead to constant hierarchy fights or conflicting situations.

Since the cause of this phenomenon is breeding, it seems to be the most effective method of prevention, when looking for the resolution of the problem also from the side of the breeding. Selection methods, in which the genetic effect of an animal on the survival of its group members is taken into account, have been shown to be very effective in reducing mortality due to feather pecking and cannibalism in laying hens (*Bolhuis et al*., 2009).

In the current genetic constructions, neglecting beak trimming may result in a 2 to 4-fold increase of mortality in laying houses. This animal welfare concern and the simultaneous change in housing technology force breeders to produce hybrids that can be successfully maintained without the need for beak-trimming that meets the new animal welfare requirements and new housing systems as well. Since the inheritance of behavioural patterns makes it possible to eliminate the aggressive individuals with abnormal social behaviour in breeding programs, a conscious selection may be a solution for the problem.

For this reason, the main goal of the present study was to examine the occurrence of mortality caused by aggression in non-beak-trimmed laying hens with different paternal origin, in order to detect aggressive and calm families in the TETRA pedigree lines. The novelty and the uniqueness of this study was the possibility of testing pure lines, which indicates the possibility of selection for this unfavourable behaviour.

MATERIALS AND METHODS

The examination was started with 1,508 Rhode Island Red (RIR) and 1,820 Rhode Island White (RIW) type day-old pullets, which were originated from 58 RIR and 70 RIW different pedigree cocks, respectively. From all of the 128 cocks 26 half sibling offspring were tested.

The pullets were raised up to 18 weeks of age in a closed building, in pens, at the Experimental Poultry Farm of the Kaposvár University, in Hungary. Offspring of five cocks (5x26) – belonging to the same type (RIR or RIW) – were reared in each pen, using deep litter floor and 14 pullets/m^2 stocking density. During the rearing period commercially available starter, grower and finisher diets were used for the *ad libitum* feeding of the animals (*Table 1*). Drinking water was also continuously available from self-drinkers.

The number of dead birds and the cause of mortality were recorded daily during the whole rearing period.

At 18 weeks of age animals were moved to the laying house of the Experimental Poultry Farm of the Kaposvár University. In the laying house, both the RIR and RIW hens were placed into three types of keeping systems (*Table 2*):

1. EU conform furnished cage (7560 cm^2 basic area; 10 hens/cage; 756 cm^2/hen);
2. Alternative pen (5,52 m^2 basic area, floor and litter combination, 53 hens/pen; 1040 cm^2/hen);
3. Conventional cage (3780 cm^2; 6 hens/cage; 630 cm^2/hen).

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Table 1
Composition of the diets used in the rearing period

Component	Diet			
	Starter I (0-3 weeks)	Starter II (4-8 weeks)	Grower (9-16 weeks)	Finisher (17-18 weeks)
Dry matter (%)	88.0	88.0	89.0	89.0
ME Poultry (MJ/kg)	12.29	12.09	11.56	11.69
Crude protein (%)	20.0	18.0	15.5	17.5
Crude fat (%)	4.33	2.93	3.33	3.44
Crude fibre (%)	4.20	4.23	3.59	4.84
Crude ash (%)	6.68	6.40	5.40	10.35
Nitrogen-free extractives (%)	56.4	60.7	63.8	57.8
Sodium (%)	0.17	0.17	0.17	0.17
Lysine (%)	1.15	1.00	0.75	0.80
Methionine (%)	0.49	0.43	0.35	0.40
Methionine + cysteine (%)	0.84	0.74	0.61	0.70
Calcium (%)	1.00	1.03	0.92	2.50
Phosphorous (%)	0.68	0.65	0.72	0.42

Table 2
Number of cocks and their offspring examined in the laying house

Lines	Keeping system						Total	
	EU conform furnished cage		Alternative pen		Conventional cage			
	Cocks (n)	Offspring (n)	Cocks (n)	Offspring (n)	Cocks (n)	Offspring (n)	Cocks (n)	Offspring (n)
Rhode Island Red								
Line 1	4	80	7	106	2	48	**13**	**234**
Line 2	20	400	9	157	6	143	**35**	**700**
Line 3	5	100	4	54	1	22	**10**	**176**
Total	**29**	**580**	**20**	**317**	**9**	**213**	**58**	**1110**
Rhode Island White								
Line 1	19	380	8	106	2	48	**29**	**534**
Line 2	20	400	9	157	6	143	**35**	**700**
Line 3	2	40	3	53	1	24	**6**	**117**
Total	**41**	**820**	**20**	**316**	**9**	**215**	**70**	**1351**

Both in the case of the EU conform and conventional cages, only the half-sibling offspring of one cock were placed into one cage. In the case of the alternative pens, offspring of 2 or 3 cocks were placed into one pen.

For the *ad libitum* feeding of the hens, commercial layer starter diet was supplied until 20 weeks of age, followed by layer feed (*Table 3*). Drinking water was continuously available from self-drinkers.

The number of dead birds and the cause of mortality were recorded daily during the whole egg-laying period, up to 72 weeks of age.

Statistical evaluation of the experimental data was performed by the Chi^2-test, using the 10.0 version of the SPSS statistical software package (*SPSS for Windows*, 1999).

Table 3
Composition of the diets used in the egg-laying period

Component	Diet	
	Layer starter (18-19 weeks)	Layer (20-72 weeks)
Dry matter (%)	89.0	89.0
ME Poultry (MJ/kg)	11.69	11.40
Crude protein (%)	17.5	17.5
Crude fat (%)	3.44	4.72
Crude fibre (%)	4.84	3.61
Crude ash (%)	10.35	14.00
Nitrogen-free extractives (%)	57.8	54.9
Sodium (%)	0.17	0.17
Lysine (%)	0.80	0.85
Methionine (%)	0.40	0.42
Calcium (%)	2.50	3.80
Phosphorous (%)	0.42	0.40

RESULTS

Mortality during the rearing period

During the rearing period – till 18 weeks of age – the following causes of mortality were recorded in the non-beak-trimmed pullet populations:

- hatching disability,
- wasting (due to feed intake refusal),
- respiratory diseases (mainly upper respiratory disorders),
- oedema,
- foot disorders,
- beak torsion,
- technological injury (caused by the keeping systems and their equipments),
- feather pecking,
- other.

The most frequent cause of mortality was *wasting*, which accounted for nearly 36% of all mortality. In addition, *feather pecking* caused also a high proportion (28.3%) of the total mortality, while the other causes of mortality did not reach 10% of the total losses. The least cause of mortality was *oedema*, which was registered only once during the rearing period.

Depending on the type of pullets (RIR or RIW), differences were observed in the frequency of occurrence of mortality causes (*Table 4*).

Table 4
Frequency of different cause of mortality in non-beak-trimmed Rhode Island Red and Rhode Island White laying hen pure lines during the rearing period (0-18 weeks of age)

Cause of mortality	Ratio of mortality in the per cent of total mortality (%)		Level of significance
	Rhode Island Red	Rhode Island White	
Hatching disability	7.3	11.7	N. S.
Wasting	48.8	25.5	P<0.05
Respiratory diseases	14.6	2.0	P<0.05
Oedema	2.4	0.0	N. S.
Foot disorder	9.8	3.9	N. S.
Beak torsion	7.3	0.0	N. S.
Technological injury	0.0	3.9	N. S.
Feather pecking	0.0	51.0	P<0.001
Other	9.8	2.0	N. S.

N. S. = non significant (P>0.05)

While nearly half of the mortality was caused by *wasting* in the RIR pullets, only one-quarter of the mortality occurred by the same reason in the RIW population. The difference in the ratio of mortality caused by wasting between the two types of the hens was statistically proven at P<0.05 level.

Respiratory diseases were responsible for 14.6% of the total loss in the RIR, while only for 2% in the RIW population. The difference between the two examined types was significant at P<0.05 level.

It was observed that certain causes of mortality occurred only in the RIR or in the RIW population, respectively. For example, *oedema* and *beak deformation* occurred only in the RIR, while *technological injury* and *feather pecking* (aggression) only in the RIW pullets during the rearing period. While aggression was not observed in the RIR population, it accounted for more than the half of the total mortality in the RIW population.

Mortality during the egg-laying period

During the egg-laying period – between 18 and 72 weeks of age – the following causes of mortality were recorded in the non-beak-trimmed laying hen populations:

- aggression (feather pecking, cannibalism),

- cloaca fissure,
- egg retention,
- wasting (due to feed intake refusal),
- pericarditis and pneumonia,
- technological injury (caused by the keeping systems and their equipments),
- poultry mite.

The most common cause of mortality was *aggression* in both of the examined types. However, while the ratio of mortality caused by aggression did not reach two-third of the total loss in the RIR hens, the rate of this was slightly higher than three-quarters of the total loss in the RIW layers (*Table 5*).

Table 5

Frequency of different cause of mortality in non-beak-trimmed Rhode Island Red and Rhode Island White laying hen pure lines during the egg-laying period (18-72 weeks of age)

Cause of mortality	Ratio of mortality in the per cent of total mortality (%)		Level of significance
	Rhode Island Red	Rhode Island White	
Aggression	64.4	76.8	P<0.001
Cloaca fission	1.1	0.0	N. S.
Egg retention	23.6	17.7	N. S.
Wasting	3.4	1.2	N. S.
Pericarditis and pneumonia	0.6	0.4	N. S.
Technological injury	4.6	0.4	P<0.001
Poultry mite	2.3	3.5	N. S.

N. S. = non significant (P>0.05)

The difference between the two types examined was statistically proven at P<0.001 level.

The second most common cause of mortality was egg retention in both examined types. While it was responsible for nearly one quarter (23.6%) of the total mortality in the RIR hens, it caused nearly one fifth (17.7%) of the total mortality in the RIW population. However, the difference between the two types examined was statistically not proven in this case (P>0.05).

The rate of any of the other causes of mortality did not reach 10% of the total mortality in any of the tested types. Among these, *technological injury* caused the greatest difference in the mortality between the two types examined. On the contrary to the growing period, 4.6% of the total mortality was caused by *technological injury* in the RIR and only 0.4% of the total mortality in the RIW hens. This difference between the examined types was statistically proven at P<0.001 level.

It was interesting to see that the ratio of mortality caused by aggression differed not only between the examined types, but also between the examined lines within the tested types. In both examined types there was found a line (Line 1 in the RIR and Line 3 in the RIW type), where the ratio of mortality caused by aggression compared to the total mortality was significantly lower than in the other two lines of the same type (*Table 6*). Among the observed causes of mortality in laying hens, *aggression* caused less mortality in alternative pens than in cages (*Table 7*).

Table 6

Mortality in non-beak-trimmed Rhode Island Red and Rhode Island White laying hen pure lines during the egg-laying period (18-72 weeks of age)

Type of hens	Line 1	Line 2	Line 3
	Total mortality (%)		
Rhode Island Red	14.1	17.0	12.0
Rhode Island White	31.8^{b}	41.4^{a}	37.6^{ab}
	Mortality caused by aggression (%)		
Rhode Island Red	5.1^{b}	11.4^{a}	8.4^{ab}
Rhode Island White	24.5^{b}	32.4^{a}	19.7^{b}
	Ratio of mortality caused by aggression in the per cent of total mortality (%)		
Rhode Island Red	36.4^{b}	67.2^{a}	70.0^{a}
Rhode Island White	77.1^{a}	78.3^{a}	52.3^{b}

^{ab}Different letters in the same row indicate significant differences (P<0.05)

In alternative pens, mortality caused by *aggression* was significantly lower (P<0.05) compared to conventional cages in both examined types. In the case of the RIW laying hens, the difference was statistically proven also compared to the furnished cages (P<0.001).

At the same time, the rate of the second most frequent cause of mortality, *egg retention*, was lowest in the conventional cages in both of the examined types. However, the effect of the housing system was statistically not proven in this case (P>0.05).

Mortality caused by *poultry mite* occurred only in the alternative housing system for both of the examined types. The rate of mortality caused by poultry mite was more than twofold higher in the RIW than in the RIR hens (21.0% and 9.3%, respectively). However, despite the great difference between the two types, the difference observed was statistically not proven (P>0.05).

By the examination of the mortality caused by aggression it was established that the paternal origin of the hens played a significant role in the appearance of aggression in both of the examined types. The ratio of mortality caused by aggression varied between 0 and 100 in the per cent of total mortality depending on the paternal origin of the hens in both types.

Table 7
Frequency of different cause of mortality in non-beak-trimmed Rhode Island Red and Rhode Island White laying hen pure lines during the egg-laying period (18-72 weeks of age) in different keeping systems

Cause of mortality	Keeping system	Ratio of mortality in the per cent of total mortality (%)	
		Rhode Island Red	Rhode Island White
Aggression	EU cage*	64.9^{bAB}	80.3^{aA}
	Alternative pen	53.5^{B}	54.3^{B}
	Conventional cage	75.7^{A}	84.2^{A}
Cloaca fission	EU cage*	0.0	0.0
	Alternative pen	2.3	0.0
	Conventional cage	2.7	0.0
Egg retention	EU cage*	28.7^{a}	18.4^{b}
	Alternative pen	20.9	19.8
	Conventional cage	13.5	13.9
Wasting	EU cage*	4.3	1.3
	Alternative pen	0.0	1.2
	Conventional cage	5.4	1.0
Pericarditis and pneumonia	EU cage*	0.0	0.0
	Alternative pen	2.3	2.5
	Conventional cage	0.0	0.0
Technological injury	EU cage*	2.1^{aB}	0.0^{b}
	Alternative pen	11.6^{aA}	1.2^{b}
	Conventional cage	2.7^{AB}	1.0
Poultry mite	EU cage*	0.0^{B}	0.0^{B}
	Alternative pen	9.3^{A}	21.0^{A}
	Conventional cage	0.0^{B}	0.0^{B}

*EU conform furnished cage
^{ab}Different letters in the same row indicate significant differences between the types of hens (P<0.05)
^{ABC}Different letters in the same column (within one cause of mortality) indicate significant differences between the keeping systems (P<0.05)

Both in the RIR and RIW type we have found cocks, whose offspring were died exclusively by aggression. However, the ratio of these cocks was significantly lower (P<0.05) in the RIR than in the RIW type (8.6% and 22.9%, respectively). On the contrary, the ratio of cocks, whose offspring did not show any loss due to aggression was 55.2% in the RIR and 15.7% in the RIW type. The difference between the two types was significant also in this case (P<0.001).

DISCUSSION

Aggressive behaviour (feather pecking and cannibalism) is a common problem in the egg production. Although beak trimming in laying hens can prevent or reduce damages caused by these behavioural disorders, this procedure has already been banned in a few European countries (*Spindler et al.*, 2016). Therefore, feather pecking is becoming a substantial problem in the layer industry, both from animal welfare and economic points of view (*Sun et al.*, 2014), especially in non-cage laying flocks (*Hartcher et al.*, 2015).

Because literature suggests that rearing is an important period for the development of behaviours later in life, *Hartcher et al.* (2015) have examined, whether behavioural tests during the rearing period could be predictive for plumage damage in adulthood. Their results indicated that environmental enrichment affected the birds' behaviour during the rearing period, but it did not affect the plumage damage due to severe feather-pecking later in life.

In the study of *Shimmura et al.* (2008) it was examined whether the hens in different housing systems have the same time budget for different beak-related behaviours. It was found that the total frequency of beak use was almost the same in the examined housing systems, but the breakdown of types of beak use was different. For example, the proportion of hens performing severe feather pecking was higher in large furnished cages and single-tiered aviary than in free-range, and more in free-range than in small and large conventional cages, and small furnished cages.

In the study of *Morrissey et al.* (2016) the authors tried to answer the question, whether non-beak-trimmed hens can be kept in commercial furnished cages. Examining the effects of breed and beak treatment on the mortality, behaviour and feather cover of the hens they have established that both of the examined traits have significant effect on the injurious pecking related mortality. However, the non-beak-trimmed hens showed not only higher mortality compared to their beak-trimmed counterparts, but also their feather cover was significantly worse at most body sites, and it worsened more quickly with age.

Bolhuis et al. (2009) have pointed out that selection could be very effective in reducing mortality due to feather pecking and cannibalism in laying hens. In their experiment hens from already the second generation of the low mortality line showed less fear-related behaviour than hens in the control line.

The effectiveness of selection for hen-days without beak-inflicted injuries was studied by *Craig and Muir* (1993). The base population was known to have a high incidence of beak-inflicted injuries when pullets' beaks were intact. After two generations, mean hen-days without beak-inflicted injuries from 16 to 40 weeks of age were 164.8 and 155.3 for selected and unselected stocks, respectively, yielding a realized family heritability of 0.65±0.13 SE. However, selection did not appear to alter the relative frequency of beak-inflicted injuries by body regions affected; about 30% of all injuries involved the vent-cloacal area.

In a later study of these authors it was examined that selection on the basis of family means for increased survival and hen-housed egg production, when sisters with intact beaks were kept together in multiple-bird cages, would cause adaptive changes in behaviour (*Craig and Muir*, 1996). Based on the results it was established that for cages with greater than or equal to 1 cannibalistic death, the commercial stock had twice and the control stock 1.6 times as many with repeated losses as the selected stock in the seventh generation. The selected stock had also better feather scores and body weights than either the control or the commercial stock.

Similarly to the results of *Morrissey et al*. (2016) we have also established that the genetic background significantly affects the presence and injury of feather pecking in non-beak-trimmed laying hens. In our examination it was observed that the differences in the mortality caused by feather pecking exist not only between the types, but also between the lines in the examined types. The examination of the paternal origin of the hens showed that – similarly to the opinion of *Craig and Muir* (1993, 1996) and *Bolhuis et al*. (2009) – selection seems be a possible way to reduce mortality due to feather pecking and cannibalism in laying hens. Based on our results selection is suggested in both of the examined types, but especially in the Rhode Island White, where significantly more cocks had mortality due to aggression in their offspring population.

According to *Spindler et al*. (2016) optimal housing and management of pullets and laying hens are also necessary if untrimmed flocks should be kept without causing increased damages due to feather pecking and cannibalism. From among the keeping systems examined the alternative pen seemed to be the most favourable in our study from this point of view.

However, despite the optimal housing and flock management, the risk of the occurrence of behavioural disorders, such as feather pecking and cannibalism cannot be eliminated completely. In practice, the access to additional environmental enrichment materials, the supply of water- and feed additives as well as the modulation of the lightning conditions in the barn, have proven effective to calm down the situation in affected flocks (*Spindler et al*., 2016).

CONCLUSIONS

Based on the results it was established that the genetic background has significant effect on the mortality caused by aggression in non-beak-trimmed laying hens. It was also pointed out that the differences in the mortality caused by feather pecking and cannibalism exist not only between the types, but also between the lines in the examined types. Because the paternal origin of the hens also showed differences in the mortality caused by aggression it was stated that selection could be a possible way to reduce mortality due to feather pecking and cannibalism in non-beak-trimmed laying hens.

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